Introduction to Transportation Engineering
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Lecture -13
Intersection Sight Distance – II

Intersection Sight Distance part II.

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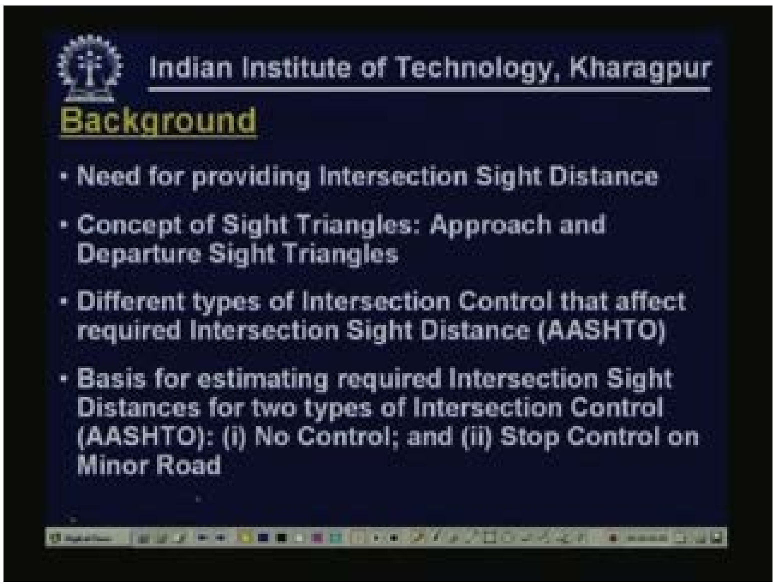

In the last lesson we discussed about the need for providing Intersection Sight Distance, why it is necessary to provide Intersection Sight Distance. We also discussed the concept of sight triangles particularly approach sight triangles and departure sight triangles. We also discussed about different types of intersection control that affect required Intersection Sight Distance particularly different intersection control as considered by AASHTO American Association of State Highway and Transport Officials.

We also discussed about the basis for estimating required sight distance Intersection Sight Distance for two particular types of intersection control namely no control and stop control on minor road. So we have seen that how or what should be the basis for estimating Intersection Sight Distance for these two types of intersection controls.

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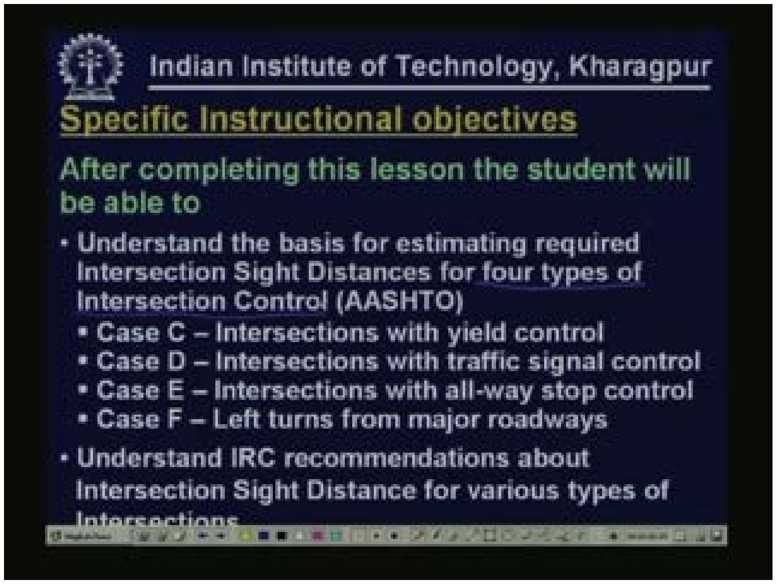

In today's lecture after completing this lesson the student will be able to understand the basis for estimating required Intersection Sight Distance for four types of intersection control considered by AASHTO like case C, case D, case E and case F. We have already discussed about case A and case B. So today we shall take up case C that is intersections with yield control, case D intersections with traffic signal control, case E intersections with all ways stop control and case F left turns from minor roadways, what should be required intersection in that case. Student will also be able to understand IRC recommendations Indian Roads Congress recommendations about Intersection Sight Distance for various types of intersection control.

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Case C) that is yield control on minor road:
This is a type of intersection where yield sign is used on minor road and drivers approaching yield sign are permitted to enter or cross the major road without stopping if there are no potentially conflicting vehicles on major road. That means whenever there is yield control or sign on minor road drivers or vehicles approaching that intersection need not stop unless and until there is any potentially conflicting vehicles on the major road. Predominantly two types of intersections are there in terms of geometry; four-leg intersection and three-leg intersection.

For four legs intersection two separate sets of approach sight triangles should be considered because the vehicles need not stop we must consider or this is the case for approach sight triangle So it is necessary to consider two different sets of approach sight triangle, one for crossing the major road and the other set for left and right turns onto the major road. So, two different types of approach sight triangles should be considered.

For three-leg intersection crossing is not a feasible maneuver so only one set that is left turn and right turn from minor road to major road should be considered. So, only approach sight triangles to accommodate left and right turn should be considered.

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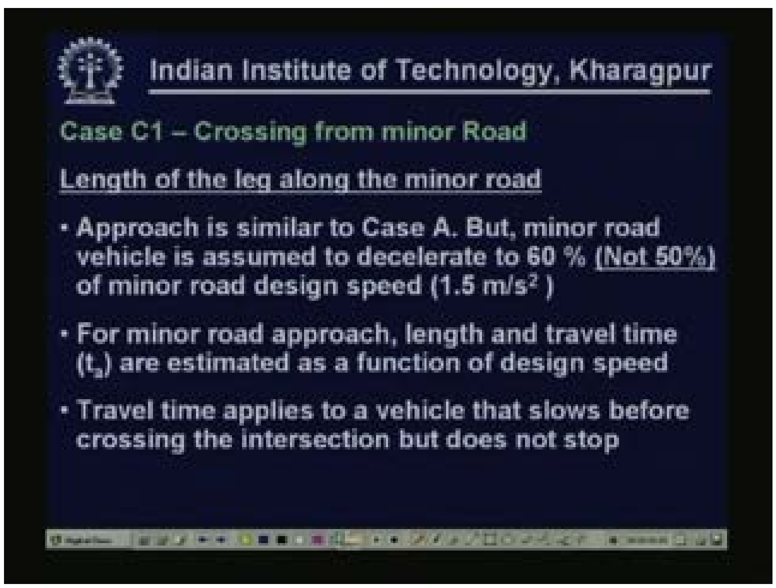

Now there are two possible sub cases as I have mentioned right now; crossing the major road and taking left turns or right turns. First case C1 crossing from major road. Now while we are discussing the required Intersection Sight Distance for yield control intersections and for crossing from major roads we have to find out the length of leg along the major road and also the length of leg the required distance along the minor road. First let us see the length of leg along major road. This approach is similar to case A.

What was case A?
Case A was the case discussed in the last session that was intersection with no control. So whatever way we calculated Intersection Sight Distance you can refresh your memory about

those considerations and here also for minor road approach the same basis is used but with slightly different assumptions. Here in this case minor road vehicles are assumed to decelerate to 60 percent of minor road designed speed. For case A or no control it was assumed that vehicles will decelerate to 50 percent of minor road design speed. So in that case it was 50 percent. In this case it is not 50 percent it is assumed to decelerate to 60 percent of minor road design speed. That means whenever vehicles are approaching a yield control intersection drivers will reduce speed approximately to 60 percent of minor road design speed with the deceleration rate up to 1.5 m/s square. This was the same deceleration rate which was assumed for case A also. Now, for minor road approach length and travel time this travel time we can refer to as ta are estimated as a function of design speed.

Let us again refer to case A. In case A or intersections with no control values for distance were recommended by AASHTO for different design speed because the assumption is vehicles decelerate to 50 percent or 60 percent of the minor road design speed. Obviously the required sight distance is a function of the approach speed. So in this case both the length and the time required to cover that distance they are given as a function of the designed speed for the minor road. Thus the table values are given in AASHTO.

Travel time applies to a vehicle that slows before crossing the intersection but does not stop.
This is a basic difference between intersection with stop control and intersection with yield control. Now here for design purpose it is assumed that vehicles will slow down, they will reduce their speed following certain deceleration and they will reduce speed up to 60 percent of the approach speed for the minor roads but the vehicles will not stop. So they will reduce the speed but they will not stop, for that condition the required time is given and we are referring that here as ta approach time.

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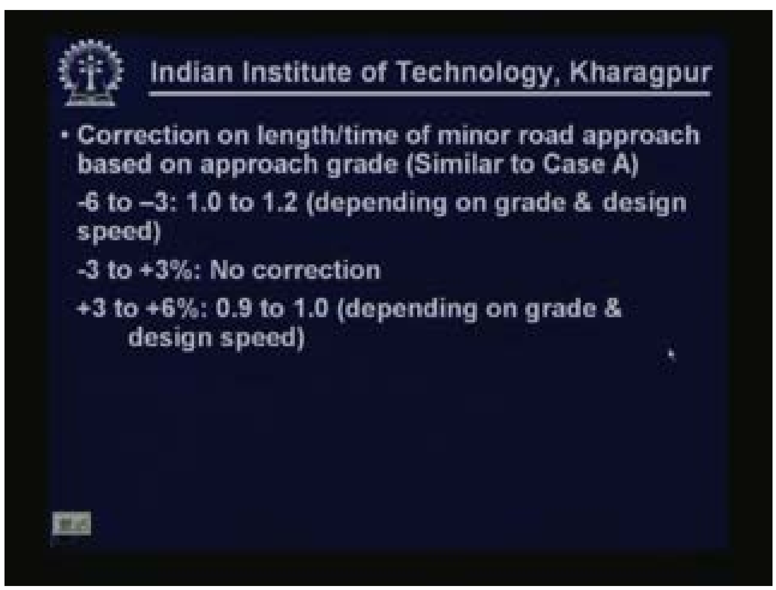

Now corrections on length of time of minor road approach is required based on approach grade.

This is again similar to what was done for case A minus 3% approach grade along the minor road. There is no need for any correction but from minus 3 to minus 6 correction factors will vary in the range 1.0 to 1.2 depending on the grade and the actual design speed. Similarly, the correction factor for plus 3 to plus 6% grade the value will vary from 0.9 to 0.1. Again depending on grade and design speed this is similar to what was used for case A to apply corrections based on grade. So a similar correction is applied here also.

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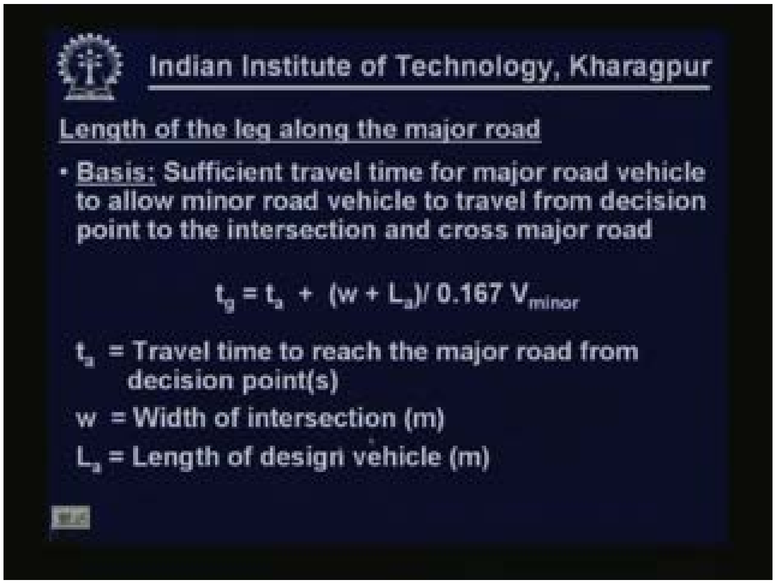

Let us see how the length of leg along the major road can be calculated. Let us try to understand the basis for this, what is the basis for doing that. The basis is sufficient travel time for major road vehicle to allow minor road vehicle to travel from decision point to intersection and then cross major road. So there are essentially two components of time. One is the time required to travel from decision point to the intersection and then time required to cross the major road. So the total time required could be estimated and the required length along the major road can be estimated accordingly.

So, if tg is the total time required then tg is expressed as ta plus w plus La divided by 0.167 V minor where V minor is the design speed or mid block speed for minor approach or the minor road. Now ta is the time, (Refer Slide Time: 15:15) this component is the time required to travel from decision point to the intersection. Just now we have discussed about this time component, now plus the time required to cross the intersection this is estimated as the width plus the length of the vehicle. So w is the width of intersection and La is the length of the design vehicle. Do remember that this is again a function of the design vehicle so it will vary depending on the design vehicle. Now this is the total distance that is required to be crossed divided by the speed. Now normally V is expressed in kilometer per hour so the conversion factor is normally 0.278. In this case carefully note that this factor is 0.167.

Now why it is 0.167?

It is because it is assumed that vehicles will reduce speed up to 60 percent of the midblock speed so 60 percent of that speed. Therefore the correction factor becomes 0.6 multiplied by 0.278 so that is approximately equal to 0.167. So it becomes the effective speed after reduction of speed to 60 percent. So now we can calculate, what will be the time required tg?

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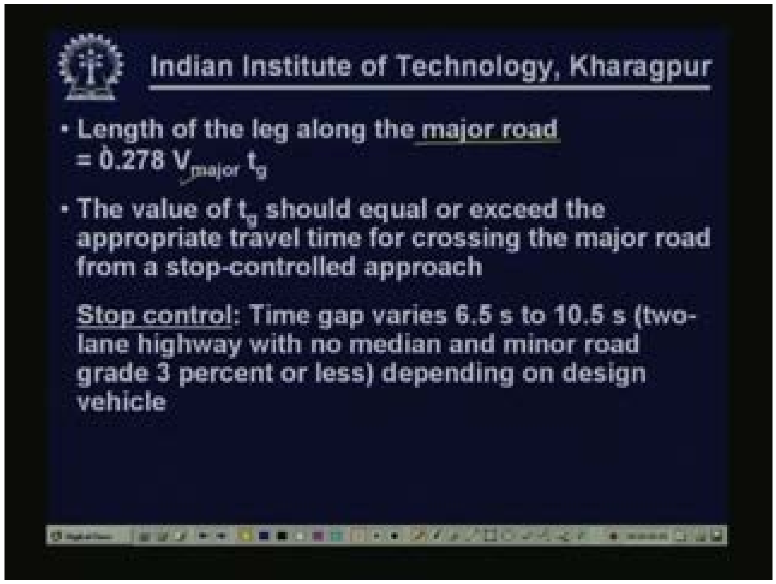

Once this time is known the length of the leg along the major road can be estimated like this; 0.278 V major remember that it is V major multiplied by tg the time gap. Now here 0.72 is the normal conversion factor because we are using V in terms of kilometer per hour. Now, in the previous page we have seen how this tg can be calculated. So once this total time gap is known what is the required length based on the design speed of the major road can be calculated. Now remember that value of tg should equal or exceed should equal or exceed the appropriate travel time for crossing the major road from a stop controlled approach.

A similar approach was also used for stop controlled intersection whatever was the value for t or the time, in that case in this case the value should equal or exceed that time value. Now let us refresh our memory, what was the actual time gap?

For stop control the time gap was 6.5 seconds to 10.5 seconds depending on design vehicle type, 6.5 seconds for car and higher values for commercial vehicle type. So when we are calculating tg using the earlier formula that is this page (Refer Slide Time: 19:08) tg then the calculated value if it becomes lesser than this time gap that is say for car it is 6.5 then we must take this value whatever is recommended for stop control approach. For example, for car if we find tg is less than 6.5 then while calculating the length of leg along major road we shall assume tg as 6.5. Similarly a different value should be assumed for other design vehicle.

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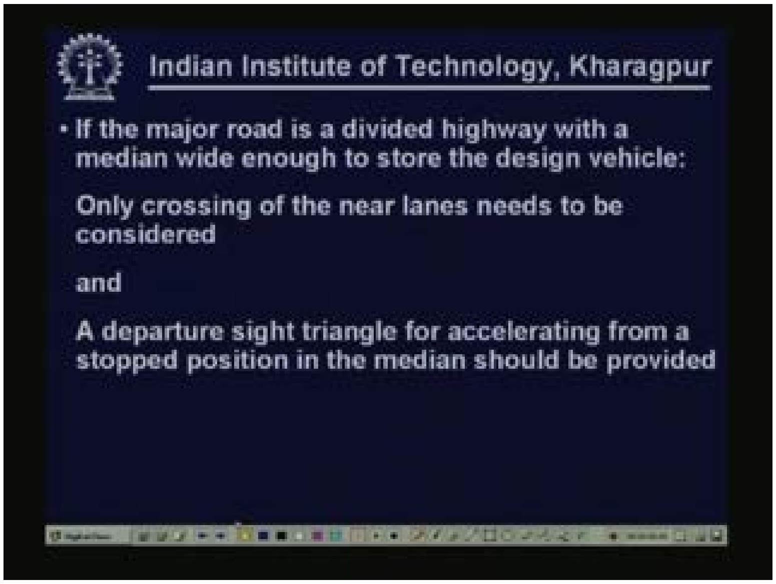

If the major road is a divided highway with median which is wide enough to store the design vehicle in that case the approach should be slightly different because till now we discussed about undivided roads. If it is a divided road and median width is sufficient to store the design vehicle then only crossing of the near lanes needs to be considered. Because near lanes crossing need not be taken into consideration along with near lanes as the design vehicle can stop using the wide median which can accommodate the design vehicle. So we shall consider crossing of near lanes only and then the vehicle can be stopped in between using the median. Therefore a departure sight triangle for accelerating from a stopped position in the median should be provided because the vehicle may stop in the median. So from stopped position obviously it will be a case for departure sight triangle. So a departure sight triangle for accelerating from a stopped position in the median should be provided.

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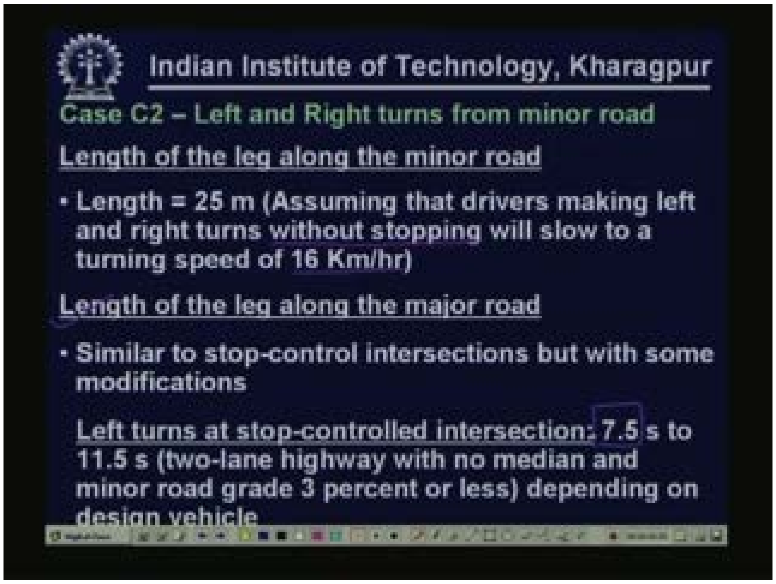

Now let us consider the case two that is left and right turns from minor roads. So, in this case also we have to see the length of leg along the minor road and also the length of leg along the major road.

Length of leg along the minor road:
AASHTO recommends the length as 25 m a fixed value. This 25 m is based on the assumption that drivers making left and right turns without stopping remember this part without stopping will slow to a turning speed of 16 km/hr. That means vehicles which are taking turn either to the left or to the right they will further reduce speed which will be acceptable or comfortable for making the turns and that speed is 16 km/hr. So considering this accept the length of leg along the minor road is recommended as 25 m.

Now let us see how the length of the road along the minor road can be calculated, length of the leg along the major road. This approach is again similar to stop control intersection but with some modification. Now let us see first what was the recommendation for left turns at stop control intersection. The time gap was recommended as 7.5 seconds to 11.5 seconds depending on design vehicle. Obviously these values are for two lane highway with no median and minor road grade 3% or less. Now this value was seven point five second for car and higher value for heavier design vehicle. Hence that was the time gap recommended for left turns at stop controlled intersection. Here minor modification is done on these design time.

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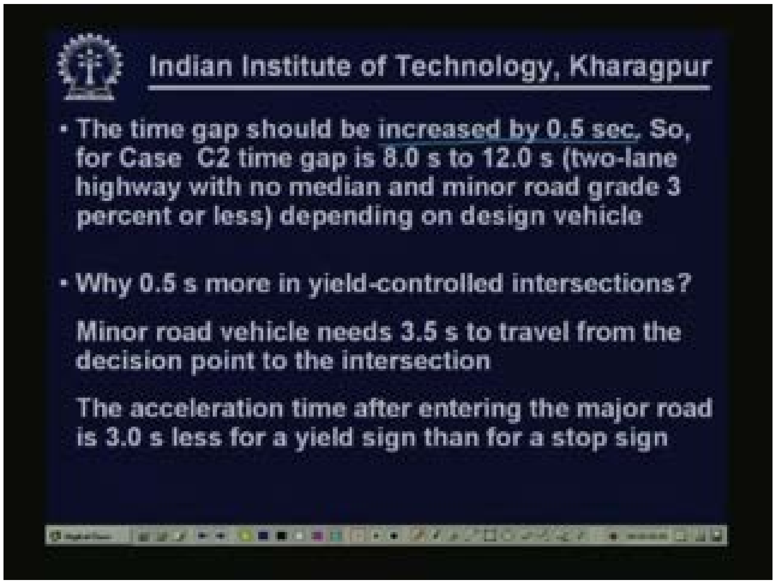

The time gap here is increased by 0.5 seconds. So earlier value for stop controlled intersection was 7.5 to 11.5. In this case it is eight seconds to twelve seconds again depending on design vehicles and this range is for two lane highway with no median and minor road grade three percent or less. So here half a second more value is assumed as compared to what was taken for stop controlled intersection. There it was 7.5 seconds to 11.5 seconds. In this case it is 0.8 seconds to 12 seconds. Now let us try to understand the basis for this increment in time by half second. Why it is increased?

It is found that minor road vehicle needs 3.5 seconds additional time to travel from decision point to the intersection for yield control approach. This component was not necessary for stop controlled intersection. So this is the additional component which is required for yield control approach. Now at the same time the acceleration time after entering the major road is three second less for a yield sign rather than or as compared to that for a stop sign. So here it is 3.5 seconds less. Why it is less? Because for yield controlled intersections it is assumed that drivers will reduce speed substantially but they will not stop. At least for the design consideration vehicles are assumed to travel at a slow speed but vehicles are not stopped whereas for stop control approach vehicles are required to stop. Therefore the acceleration time will definitely be higher for stop control approach because vehicles will start from zero speed; in this case it is not zero speed so there is easy saving of three seconds. So there was additional time requirements of 3.5 seconds and there is a saving of 3.5 seconds. So as a net result it is half a second more time that is required for yield control intersection. That is why the time gap is taken as eight seconds to twelve seconds depending on the design vehicle.

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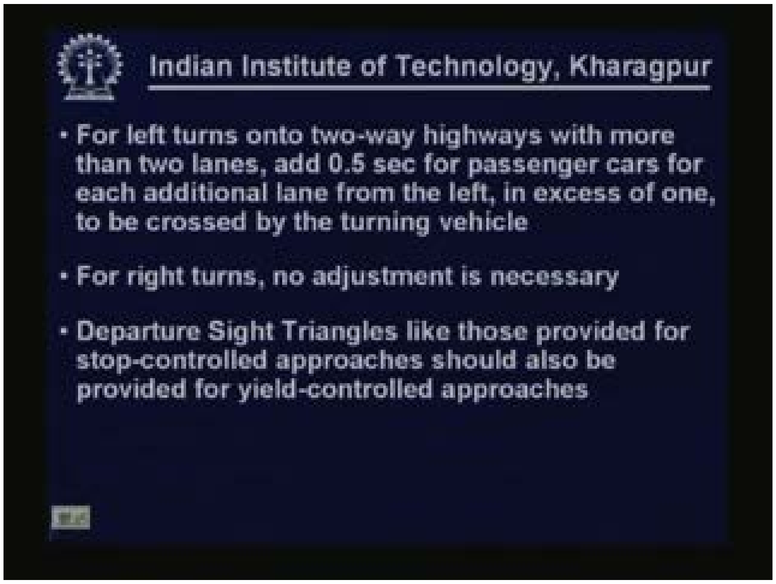

For left turns on two-way highway with more than two lanes 0.5 seconds should be added if the design vehicle is passenger car and for each additional length from the left in excess of one that is to be crossed by the turning vehicle. So I have mentioned it that the values which were mentioned earlier 0.8 seconds to twelve seconds they are for two lane highway. So if a more wider highway is considered for left turns then corrections should be applied depending on design vehicle and the number of lanes that is to be crossed in excess of one by the turning vehicle. So that value is 0.5 second for passenger car and a different value is suggested for other design vehicles.

For right turns of course no such adjustment is necessary.

Departure sight triangles like those provided for stop-controlled approaches should also be provided for yield-controlled approaches. This is because of the fact that if there is a conflicting vehicle then vehicles approaching from minor road also may have to stop. So if they stop then the departure sight triangle will be an appropriate consideration. So departure sight triangle like those provided for stop controlled approaches should also be considered.

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Normally no specific check for departure sight triangles at yield controlled intersections is needed as approach sight triangles for turning maneuvers at yield control approaches are larger. So if we design sight distance considering yield control approach and considering the left turn and right turn without stopping then the required sight distance whatever will be obtained will normally be larger than the stop controlled requirement. So no specific check is normally required.

If sight distance sufficient for yield control is not available then one may recommend or one may explore the possibility of using stop sign instead of yield sign because then it will be a stop controlled intersection and the required sight distance will be less as compared to yield control intersection.

Further at locations where recommended sight distance cannot be provided one should explore the possibility of installing regulatory speed sign or other traffic control devices on the major road. Remember that we are talking about on the major road to reduce approach speed of vehicles from major road because you have seen that for a given time gap the actual length required will depend on the design speed. So, if a regulatory measure is taken to reduce the speed either by regulatory speed sign or with the help of other traffic control devices then the required sight distance along the major road can be reduced or can be minimized.

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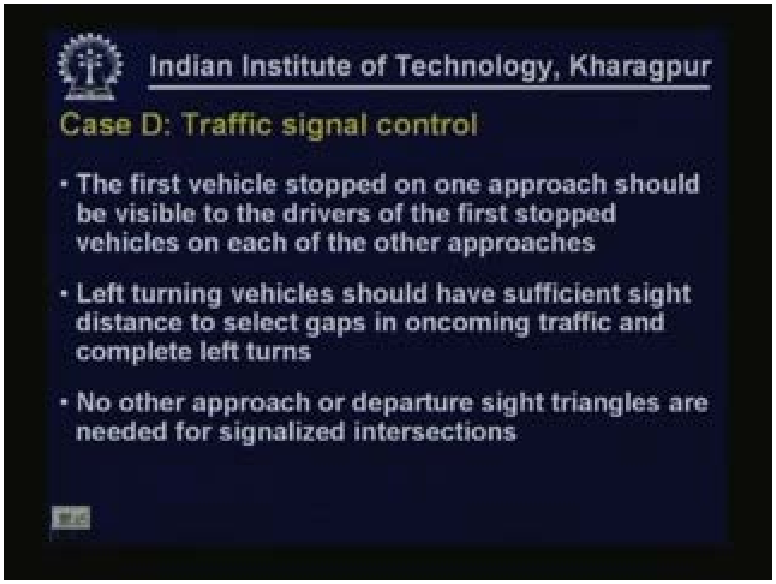

Now let us see the case D that is traffic control or traffic signal control, intersections which are controlled by traffic signal. In this case the consideration for sight distance is based on the fact that the fast vehicle stopped on one approach should be visible to the drivers of the first vehicle of all other approaches. In addition, for left turning vehicles left turning vehicles we are saying considering US convention of driving. In Indian condition this is actually the right turn. So left turning vehicle should have sufficient sight distance to select gaps in oncoming traffic and complete left turn. This is the additional consideration that may be taken. No other approach or departure sight triangles are needed for signalized intersections.

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In fact signalization may be an appropriate crash countermeasure for higher volume intersections with restricted sight distance and those which have experienced intersection related problems and crashes. Now there is another special consideration for signal intersection or signal control they are as follows:

If the traffic signal is to be placed on two-way flashing operation, what you mean by two-way flashing operation is like this.

Flashing yellow on the major road approaches and flashing red on the minor road approaches under off-peak or nighttime conditions.

If this is the operating condition then this is necessary to provide appropriate departure sight triangles for case B for the minor road approaches because vehicle may stop. So in that case whatever considerations we have discussed for case B that is for stop control approach intersection with stop control on minor road that is to be applied.

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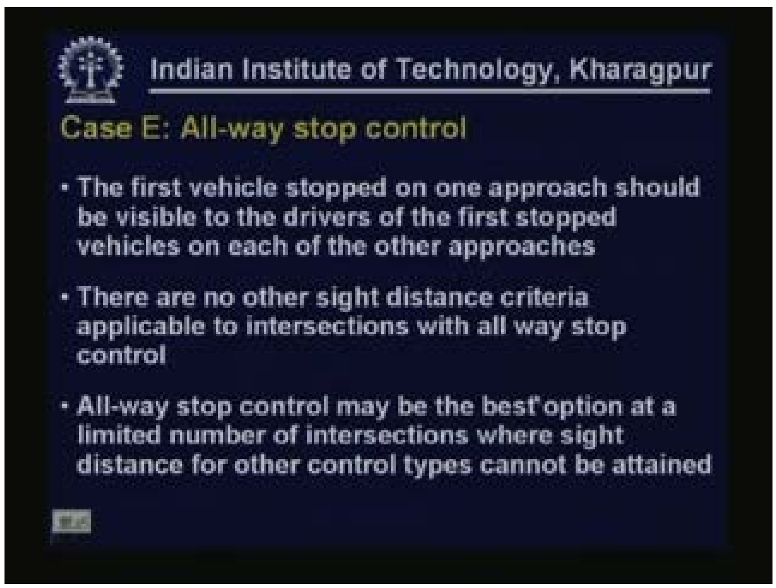

Case E: All-way stop control:

In this case also like signal control the fast vehicles stopped on one approach should be visible to the drivers of the fast vehicle stopped on each other approaches. There are no other sight distance criteria applicable for intersections with all-ways stop control.

In fact all-way stop control may be the best option at a limited number of intersections where sight distance from other control types or sight distance required for other control types cannot be attained. So in those cases in a limited number of intersections one can go for all-way stop control for simplicity and for enhanced safety in terms of the sight distance availability.

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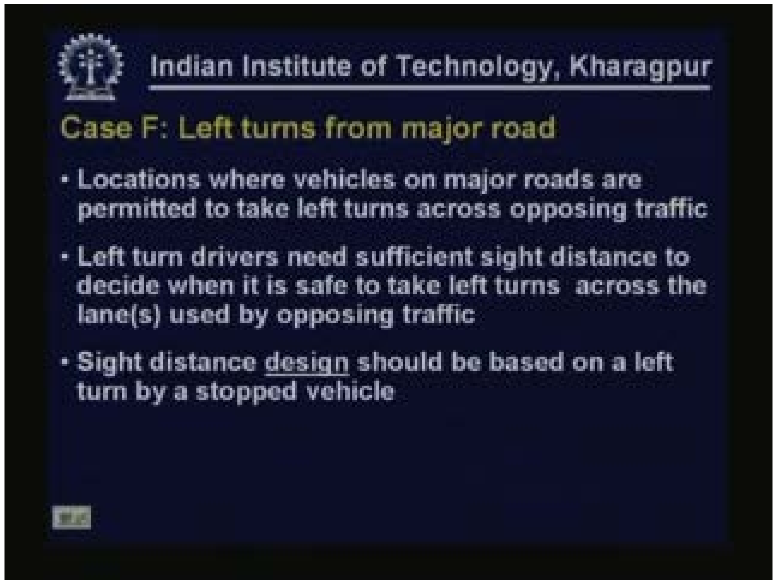

Case F: Left turns from major road:
Here we are talking about locations where vehicles on major road are permitted to take left turns across opposing traffic. Remember that again we are using US convention of driving so the vehicles are permitted to take left turns across opposing traffic. If this is the vehicle which is traveling along the major road they have to take left turn like this against this opposing traffic. Therefore left turn driver needs sufficient sight distance to decide when it is safe to take left turns across the length used by opposing vehicle and sight distance design should be based on the left turn by a stopped vehicle.

Now carefully observe this word design. Design should be based on a left turn by a stopped vehicle. Now why it is stopped vehicle?
The reason is if vehicle is in motion then it will normally require a lesser sight distance as compared to a vehicle which is stopped. Therefore for design consideration it is considered that a vehicle is taking left turn and that vehicle is a stopped vehicle. So, if the available sight distance is sufficient to satisfy this requirement then automatically it will satisfy the requirement of those drivers which will take left turn without stopping. That's why it is based on a left turn by a stopped vehicle.

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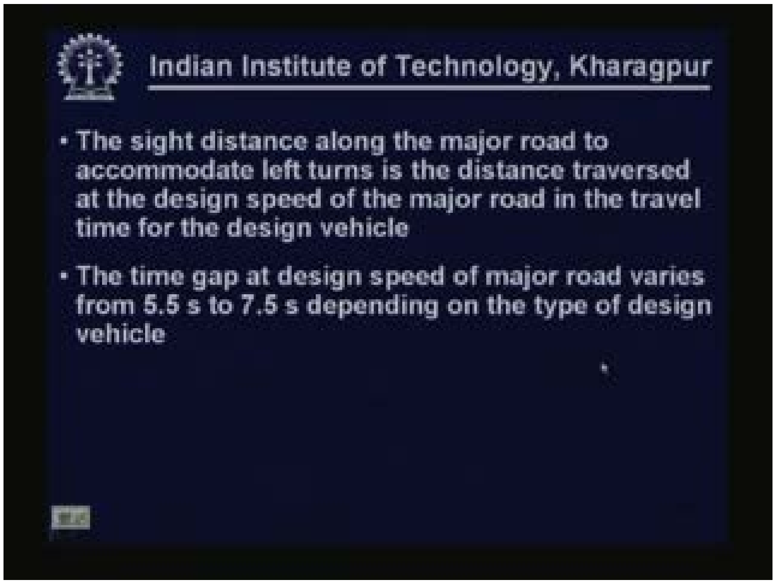

The sight distance along the major road to accommodate left turns is the distance traversed at the design speed of the major road in the traveled time for design vehicle. Whatever traveled time is required for the design vehicle to complete this left turn that much time whatever distance is covered by a vehicle which is traveling along the major road in design speed will give us the length or the required sight distance along the major road. So this time gap as per AASHTO is 5.5 seconds to 7.5 seconds that is the time gap which is recommended by AASHTO based on the field observations. And this value 5.5 seconds to 7.5 seconds varies depending on the type of design vehicle. So, for passenger cars it is 5.5 seconds for heavier vehicles commercial vehicles if they are taken as design vehicle then the required time is higher and it may go up to 7.5 seconds. So whatever is the distance covered along the major road if major road speed is V major then 0.278 into V major into this appropriate time 5.5 to 7.5 depending on the design vehicle that will give us the required length.

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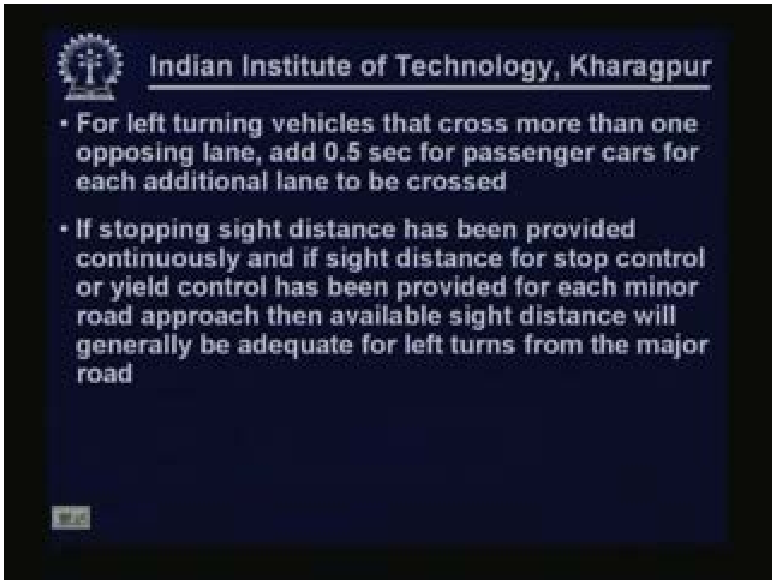

Let us see there are a few more aspects.
For left turning vehicles whatever values we have mentioned in the last slide 5.5 seconds to 7.5 second are actually for two-lane road for turning vehicles or left turning vehicles that cross for more than one opposing length. So point five seconds should be added for passenger car and a separate value is recommended for other vehicle types design vehicle for each additional length to be crossed. Obviously if it is a wider road more number of lengths are to be crossed so therefore more time is required. So AASHTO recommends that 0.5 seconds for passenger car should be taken for each additional length to be crossed.

Now, if Stopping Sight Distance has been provided continuously normally throughout the length of the highway Stopping Sight Distance is provided. Therefore if Stopping Sight Distance is provided at all points along the highway and if sight distance for stop control or yield control has also been provided for each minor road approach then available sight distance will generally be adequate for left turns from the major road. So separate consideration or separate checks may not be necessary. Therefore if throughout the length of the road Stopping Sight Distance is available and at all minor intersections with stop control or yield control appropriate Intersection Sight Distance is available then normally it is not necessary to check for the requirement of sight distance for left turning traffic because normally the sight distance should be adequate for this kind of maneuvers. With this we have completed our discussion about all six different types of control considered in AASHTO and the basis for Intersection Sight Distance for each control type.

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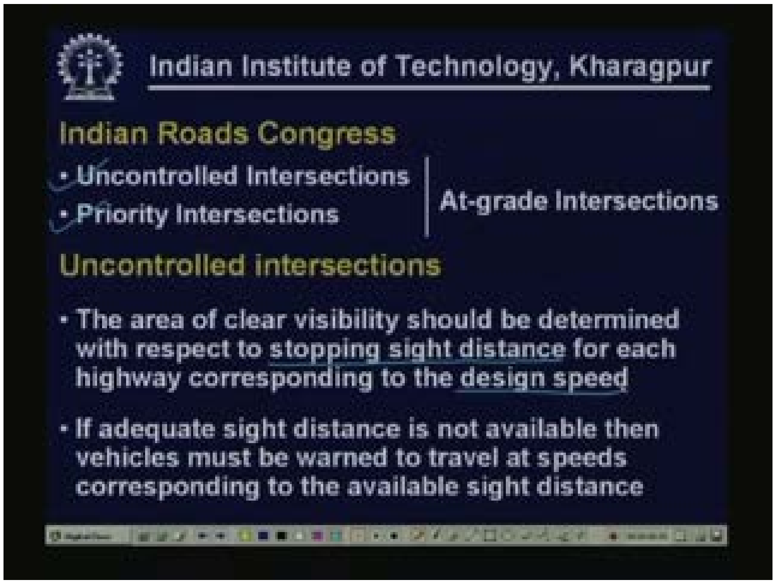

Let us look at the Indian conditions particularly the recommendations given by Indian Roads Congress. IRC considers two different types of at-grade intersections; one is uncontrolled intersections as indicated here, the other set is priority intersections.

The uncontrolled intersections are those intersections where priority of both roads are equal. No special or no higher priority or lower priority for any road. Both intersecting roads normally have equal priority.

For priority intersections priority of one road is higher than the priority of the other road.
So it is the case where a major road and a minor road are intersecting. Let us see the IRC recommendations first for uncontrolled intersections.

The area of clear visibility should be determined with respect to Stopping Sight Distance for each highway corresponding to design speed. That means IRC straight way recommends that each approach should be equal to the required Stopping Sight Distance depending on the design speed for that approach. So, if there are two roads and the design speeds are different then one can easily calculate the required Stopping Sight Distance corresponding to the design speed of road one and also corresponding to the design speed of road two and that will give us the dimensions for the sight triangle. So straight away it says that it should be on the basis of Stopping Sight Distance. And the basis used in IRC for Stopping Sight Distance is what we have already discussed earlier.

Now if adequate sight distance is not available then vehicles must be warned to travel at speeds corresponding to the available sight distance. That means if due to cost considerations suppose the required area is not available clear area is not available and there is an obstruction where it is very expensive or costly to remove that obstruction in that case we may still compromise with the lesser dimensions of sight triangle but in that case approach speed is to be modified. So it says that vehicle must be warned to travel at speed corresponding to available sight distance.

One can see what is the available sight distance and what speed that sight distance can accommodate. So accordingly there should be speed restrictions. Now it could be done like, on both roads one can restrict the speed or it could be done the other way like, for one road one can assume the design speed and then on the other road whatever is the available sight distance accordingly the speed restrictions can be imposed on the other road. But the basis is SSD or the Stopping Sight Distance.

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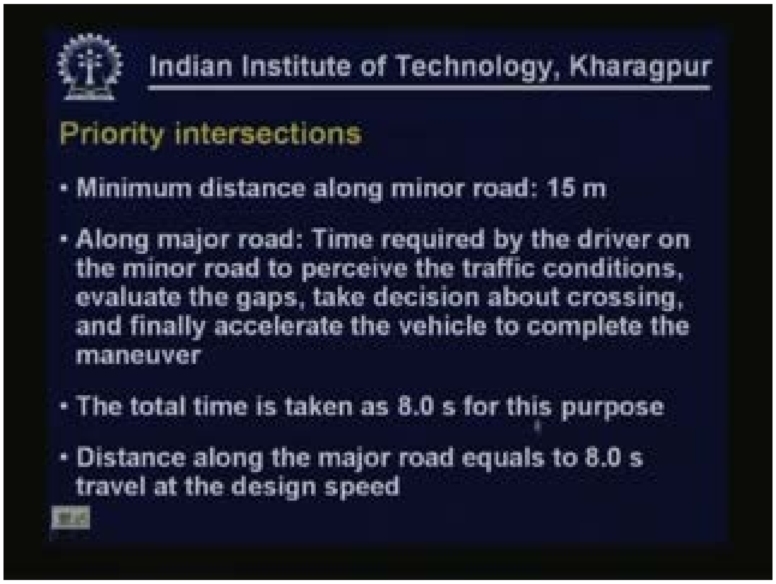

For priority intersections we have to find out the minimum distance along the major road and the distance along the minor road to get the required sight triangle.

The minimum distance along the minor road as per IRC is recommended as 15 m for design purpose. For all priority intersection this is 15 m.

Along the major road the basis is the time required by the driver on the minor road to perceive traffic conditions part one. Part two; evaluate the gap, part three; take decision about crossing and part four; finally accelerate the vehicle to complete the maneuver. So, for all these components it is the total time whatever is required for vehicles along the minor road. So, accordingly that time is taken as 8 seconds and distance along the major road equal to 8 seconds travel at design speed is recommended. That means the distance along the major road is 0.278 into V major that means design speed for the major road multiplied by t that is 8 seconds so that will give us the length.

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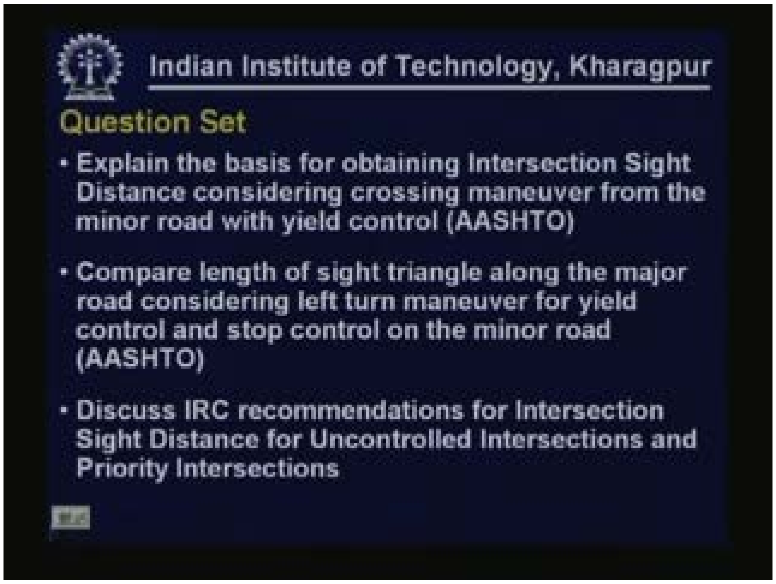

Now let us try to answer some of the questions:
Explain the basis for obtaining Intersection Sight Distance considering crossing maneuver from the minor road with yield control. This is what is the basis used in AASHTO for this particular situation.
2) Compare length of sight triangle along the major road considering left turn maneuver for both yield control intersection and stop control on minor road, compare that length as obtained for yield control intersection and as obtained from stop control on minor road.
3) Discuss IRC recommendations for Intersection Sight Distance for uncontrolled intersections and priority intersections.
Try to answer to these questions. Now I shall quickly try to answer the questions which were raised during lesson 3.5.

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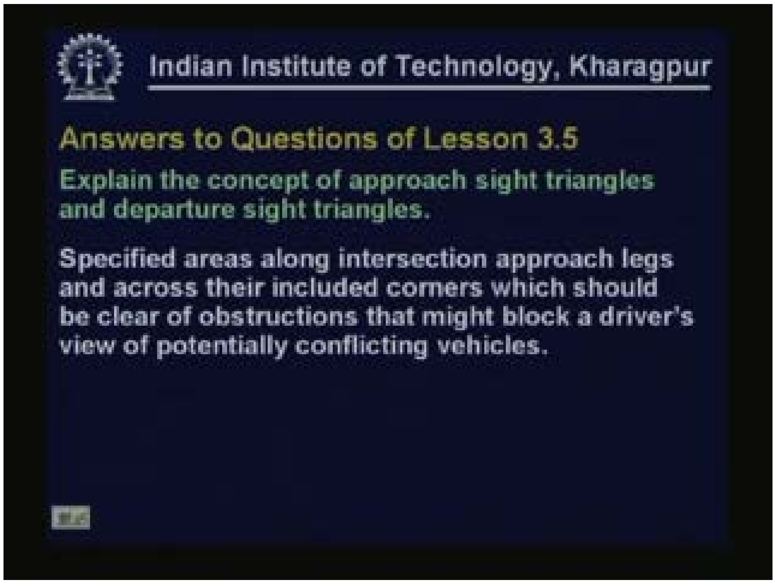

Explain the concept of approach sight triangles and departure sight triangles.
Let us see what is the sight triangle?
Sight triangles is the specified areas along intersection approach legs and across their included corners which should be clear of obstructions that might block a driver's view of potentially conflicting vehicles.
So you have the major road and a minor road, what is the triangular area that should be free from obstruction that is sight triangle.

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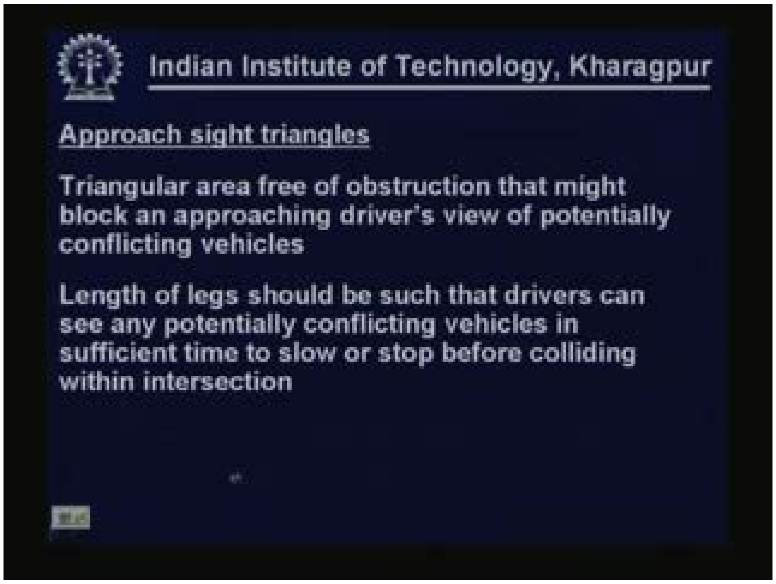

The approach sight triangle is the triangular area free of obstruction that might block an approaching driver's view. That means vehicle is in motion of potentially conflicting vehicles.

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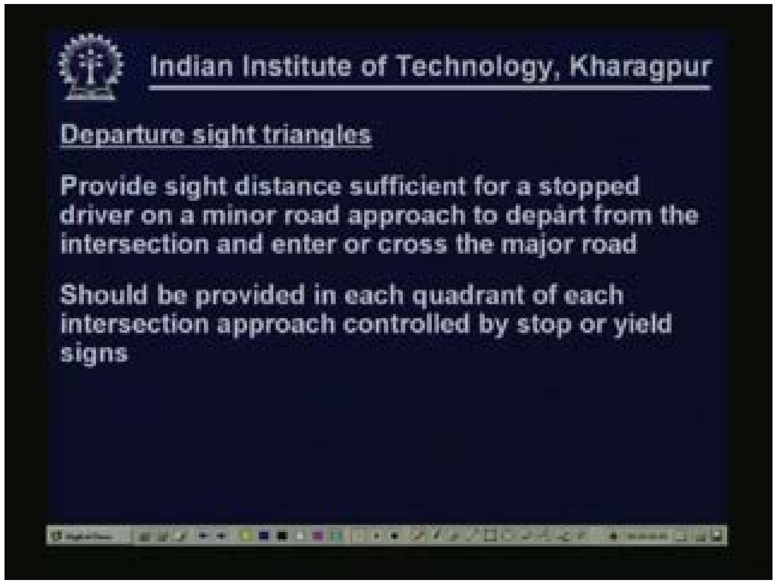

For departure sight triangles it is the same sight triangle same concept but here it is to provide sight distance sufficient for a stopped driver on a minor road approach to depart from the intersection and enter or cross the major road. So one case approach sight triangle is for moving vehicles, departure sight triangles is for stopped vehicles.

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Next question was mention different types of intersection control considered by AASHTO for the estimation of Intersection Sight Distance.

Different intersection controls are; A no control, case B stop control on minor road, case C yield control on minor road, D traffic signal control, case E all-way stop control and case F left turns from minor road. So AASHTO considered all these six cases.

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The last question was for an intersection with stop control on minor roads what should be the dimension of sight triangle considering left turn from minor road?
Design vehicle is car, design speed for the major road is 100 Km/hr, major road is a full and divided road and minor road approach is located on a 4% upgrade.

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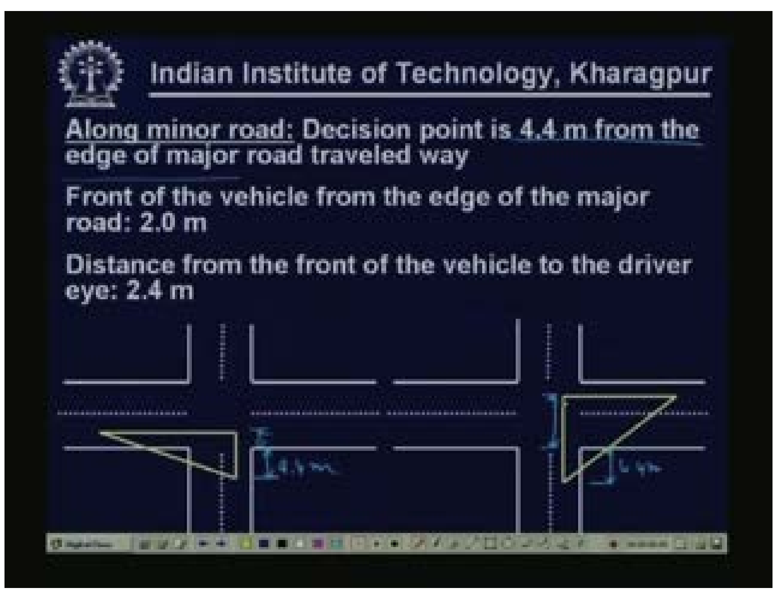

Along the minor road the decision point is 4.4 m from the edge of the major road so this is the distance which is 4.4 m.

Now what should be the length of additional length that is this length and in this case considering the traffic from right this length that can be obtained easily considering the width of the road.
So if it is a full length road accordingly one can calculate.

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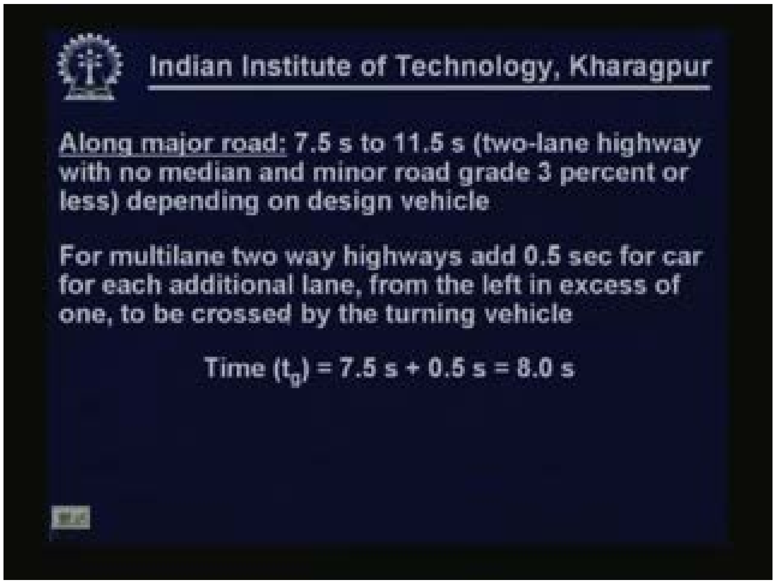

Along the major road normally it is 7.5 seconds to 11.5 seconds that is for car. But for multilane highway 0.5 seconds for each additional lane is to be added that is to be crossed by the turning vehicle . Since it is a full length road so one additional lane is to be crossed. Instead of one lane it is to be two lanes so 0.5 second is added making it 0.8 seconds and that's the effect of width.

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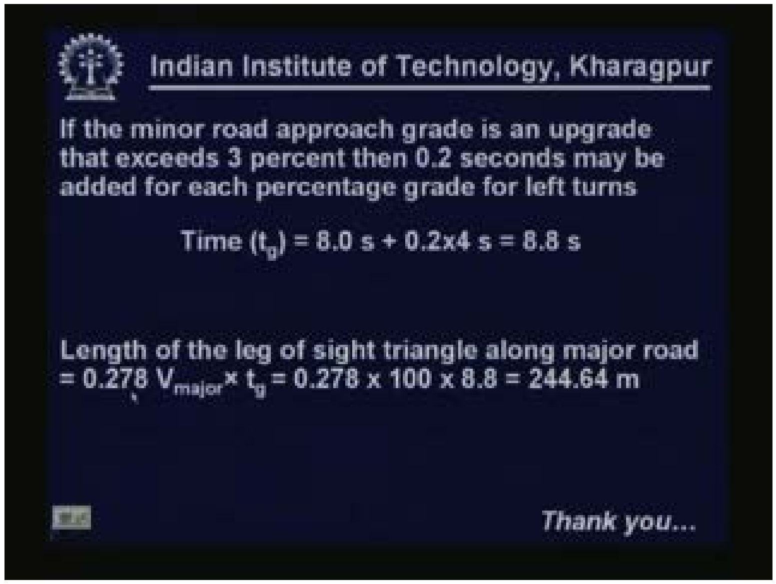

Now what is the effect of grade?
AASHTO says that in excess of 3% 0.2 seconds may be added for each percentage grade.
So if it's a 4% grade means 4 into 0.2 that is 0.8 seconds. So total is 8.8 seconds.
The approach speed is known so the length is 0.278 into 100 km/hr into 8.8 so that gives us 244.64 m so that way one can calculate the length. Thank you